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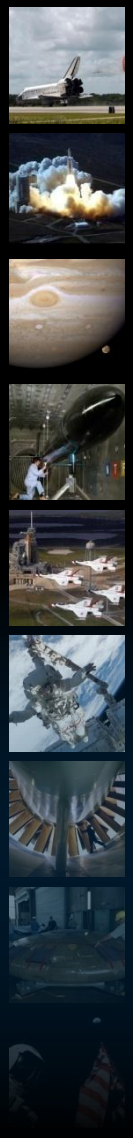

Through a New Lens

Apollo, Challenger and Columbia Through the Lens of NASA's Safety Culture Five-Factor Model

Senior Management ViTS Meeting

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This and previous presentations are archived at
sma.nasa.gov/safety-messages

INTRODUCTION

Ten years after the inflight breakup of Space Shuttle Columbia, Space Transportation System Mission (STS-107), the memory of those astronauts — and of Apollo 204 in 1967, and Challenger in 1986 — who died in the line of service continues to serve as a reminder to the agency.

The Five Factors of NASA Safety Culture

- **Reporting Culture**: we report our concerns without fear of reprisal
- **Just Culture**: we treat each other fairly
- **Flexible Culture**: we change and adapt to meet new demands
- **Learning Culture**: we learn from successes and failures
- **Engaged Culture**: everyone does their part

- We dedicate this examination of failures during the Apollo and Shuttle programs to the difficult and groundbreaking work of NASA personnel. They achieved an incredible record of mission success and scientific achievement. Isolating failures in case studies sustains vigilance against future recurrence as new generations take over the construction and flight of spacecraft — especially crewed vehicles.

- ***"No one wants to learn by mistakes, but we cannot learn enough from successes to go beyond the state of the art." –Henry Petrosky***

REPORTING CULTURE

We report our concerns without fear

- Before the 1967 Apollo fire, multiple decentralized reporting systems created an opaque, “structurally secret” environment where the organization prevented knowledge sharing.

- Apollo astronauts aggressively identified crew safety issues related to all aspects of flight to design engineers and NASA managers. Design engineers adopted some crew suggestions but dismissed others the crew deemed critical — resulting in the Apollo fire.

- As result, a central system collected all failures. The program manager required technicians to report close calls as “problems,” under the new Problem Reporting And Corrective Action (PRACA) concept.

After the Apollo 204 fire, NASA sought to promote greater flight safety awareness with a symbol much like the United States Forest Service’s Smokey Bear.

- After the Challenger loss, Shuttle program manager Arnold Aldrich described a lack of reporting and inadequate trend analysis to the Rogers Commission. This moved the commission to include findings in a chapter titled “The Silent Safety Program,” calling for a PRACA revival.

JUST CULTURE

We treat each other fairly

- In each mishap, evidence shows how excessive risk was second to other priorities. After many efforts to point out hazards in the Apollo 1 command module, Gus Grissom hung a lemon outside the capsule as a sign of poor quality.

- Managers conducted the Marshall Space Flight Center-Thiokol telecon like a formal flight review even though it was not. Some felt surprised when expected to defend an engineering position against the weight of past Go decisions. Managers judged weak signals as weak justification to delay launch. Some interviewed later expressed feelings of intimidation to speak out in a perceived environment of, "Prove it's not safe."

Source: NASA.

- In a just culture, recurring willful violation of rules requires accountability proportional to the violation. Unintentional slips or decisions with devastating outcomes call for training or non punitive management.

FLEXIBLE CULTURE

We change to meet new demands

- The highly complex Shuttle Program produced a four-layer, rule-driven culture that drove design and review processes to accommodate the production of flights in an “operational” environment.
- In both the Challenger and Columbia mishaps, processes allowed successive review panels to approve launches despite the lack of solid test data or counter to design specifications.
- Multilevel reviews mixed with an imperative to resolve problems to an acceptable risk level and fly, masked engineering uncertainty to comprehend the performance of the Solid Rocket Booster (SRB) joint and External Tank foam systems.
- Decisions on problems were made at each review level. The lack of perceived flexibility to test the design and fix flaws created an atmosphere that demanded problems be sketched in progressively lesser detail and more certainty when presented to the next higher level.
- Each mission success seemed to validate each previous “go” review decision that inched away from design intent.

Shuttle Flight Readiness Review. Source: NASA

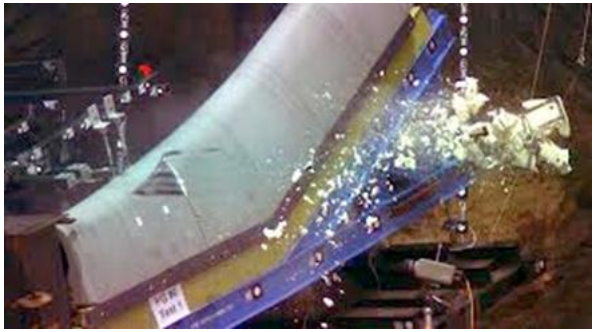
LEARNING CULTURE

We learn from our successes and mistakes

- After the Apollo fire, a “zero-defect” approach developed in every engineering and management domain to achieve mission success. Space hardware, like a re-designed Command Module, benefited from adoption of many previously identified hazard barriers and controls.

- Post-mishap, the Apollo program welcomed a new focus on quality, reliability and maintainability, and system safety engineering. Safety and mission assurance specialists joined the team in those areas for the first time. Above all, better planning and communication drove rigorous component-level and end-to-end testing.

- Historians credited Apollo post-mishap technical success to use of first-order data from well-designed tests. Apollo work involving engineers at every NASA Center and many aerospace companies created a synergistic effect that transcended the program and changed aspects of NASA activities for decades after the program ended.



Foam debris test performed after Columbia mishap. Source: NASA

ENGAGED CULTURE

Everyone does their part

- Apollo and Shuttle program personnel engaged in dramatic fashion to do their respective parts after the Apollo fire, Challenger explosion, and Columbia inflight breakup.

- Management's freedom to place safety ahead of cost and schedule following Columbia allowed a safe flyout of the remaining Shuttle missions. This route was necessary to restore technical margins of safety, quality, and reliability.

- The Five Factors of NASA Safety Culture can help all NASA employees interpret weak and mixed signals and reach sound decisions in the face of uncertainty. Our commitment to these principles is vital as NASA and commercial companies move forward to work in cooperation in the fields of aeronautics and space.

- Try looking at your own project or organization and asking, "How am I behaving with respect to the Five Factors of NASA Safety Culture?"

- For NASA employees and support service contractors with SATERN learning management system accounts, you can take the Orientation to NASA Safety Culture course Course HQ-SMA-ONSC at https://satern.nasa.gov.